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National Marine Fisheries Service Permit No. 1010 Annual Report

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INTRODUCTION

Permit 1010 authorizes the take of Endangered Species Act (ESA) listed spring/summer chinook salmon *Oncorhynchus tshawytscha* by the Idaho Department of Fish and Game (IDFG) for scientific research and enhancement activities associated with the development of captive rearing techniques. This permit covers activities performed in a captive rearing program including the annual collection of eyed-eggs and/or sub-adults, transportation and allocation of individuals to rearing facilities, culture methodologies, tagging procedures, adult releases, and post-release behavioral observations. This permit also requires a report to be submitted to the National Marine Fisheries Service (NMFS) annually that details the research and enhancement activities performed during the previous year. The objective of this report is to satisfy these requirements.

The Captive Rearing Program for Salmon River Chinook Salmon was initiated by the IDFG in 1995 under the authority of NMFS Permit No. 972. The goal of this project is to develop and test captive rearing methodologies to determine if this strategy can be developed into effective intervention tool to provide short-term relief for severely depressed local chinook salmon populations. Successful development of captive rearing techniques will ensure that a minimum number of adults from target populations are present to spawn, thereby maintaining the continuum of smolt production. The project began in 1995 with the collection of brood year 1994 parr and smolts. Fish from each subsequent brood year have been represented in the program. Prior to 1999 juvenile chinook salmon were primarily collected by screw traps as either parr or smolts. Culture groups collected in this way are referred to as natural parr groups or by the acronym NP. In 1999, collections shifted primarily to eyed-eggs to correct limitations

associated with fish health, skewed sex ratios, and conversion to hatchery diets. Culture groups established through egg collections are referred to as natural egg groups or by the acronym NE. In 2001, all collections were made at the eyed-egg stage. After collection, eggs are reared at the IDFG Eagle Fish Hatchery (Eagle) until smoltification. At that time approximately 75% of the smolts are transferred to the NMFS Manchester Marine Experimental Station, Manchester, Washington (Manchester) for rearing to maturity in salt water. The remaining 25% are kept at Eagle to guard against catastrophic loss at the NMFS facility. Mature adults from this program are generally released back into their natal streams to spawn, although some hatchery spawning has occurred. Hatchery crosses (referred to as "Safety Net" or SN groups) have been used to ensure brood year representation when natural escapement was deemed insufficient to produce enough juveniles to support collections by this project without adversely affecting the wild population. Eyed-eggs produced from hatchery crosses beyond the project's need have been provided to cooperators with the Shoshone–Bannock Tribes for use in streamside or in-stream incubators.

Eyed-eggs for this project are collected using hydraulic sampling methods described by McNeil (1964). This system consists of two main components. The first is a gasoline-powered pump attached to a 3.8-cm diameter aluminum probe via flexible tubing. Holes drilled near the top of the probe infuse air into the water-stream through venturi action. The second component is the collection net frame, which consists of a "D" shaped aluminum frame with expanded plastic mesh along its curved portion and netting around the bottom and sides of its straight portion. When the pump is operating, water is forced through the probe, which is worked into the substrate within the net frame. The air/water mixture lifts eggs out of the substrate, where they are swept downstream into the net. The expanded plastic screen confines eggs lifted out near the periphery and directs them into the net. In order to minimize disturbance to the redd, sampling is usually begun slightly below estimated nest pocket locations and progresses upstream. This prevents fine materials lifted out of the substrate from settling back into the redd and possibly smothering the remaining eggs. Care is also taken to keep sampling personnel behind or to the side of the net frame to minimize redd trampling.

YEAR 2001 PERMIT ACTIVITIES

Naturally spawned, eyed-eggs were collected from the East Fork Salmon River and the West Fork Yankee Fork Salmon River in 2001. Chinook salmon in these streams are part of the Snake River Salmon Evolutionary Significant Unit, so 100% of the project's take were ESA listed individuals. Eggs were collected from six redds in the East Fork Salmon River on September 18 and 26, 2001, and from six redds on the West Fork Yankee Fork Salmon River on September 19 and 27, 2001 (Table 1). Eyed-egg collections for the establishment of brood-year 2001 captive culture groups totaled 311 from the East Fork Salmon River and 272 from the West Fork Yankee Fork Salmon River (Table 1).

Table 1.–Summary of eyed-egg collections in the East Fork Salmon River (EFSR) and West Fork Yankee Fork Salmon River (WFYF) to establish brood-year 2001 culture groups for the chinook salmon captive rearing program.

Date	Stream	Redd 1	Redd 2	Redd 3	Total
9/18/01	EFSR	41	6	48	95
9/26/01	EFSR	71	50	95	216
	EFSR				311
9/19/01	WFYF	9	77	2	88
9/27/01	WFYF	73	70	41	184
	WFYF				272

Transportation events during 2001 included three smolt transfers from Eagle to Manchester, four maturing fish transfers from Manchester to Eagle, one mature fish transfer from Eagle to the West Fork Yankee Fork Salmon River, and two eyed-egg transfers from Eagle to Bear Valley Creek (tributary of the Lemhi River). Smolt transfers from Eagle to Manchester occurred on April 30, May 7, and May 10, 2001 and included 178, 242, and 210 fish from the East Fork Salmon River, West Fork Yankee Fork Salmon River, and Lemhi River, respectively (Table 2). Maturing adults were transferred from Manchester to Eagle on four dates in 2001 (Table 2). Fish determined to be maturing in the initial maturation sort were transferred on the following dates: brood-year 1998 culture groups May 8 and 11, 2001 and, brood-year 1996 and 1997 culture groups June 6, 2001 (Table 2). Fish from all culture groups determined to be maturing in the second maturation sort at Manchester were transferred to Eagle on August 2, 2001 (Table 2). An estimated 8,130 eyed-eggs were transferred to in-stream incubation boxes in Bear Valley Creek on October 18 and November 1, 2001. These eggs were produced from spawning 26 Lemhi River females at Eagle between September 14 and October 10, 2001. Cooperators with the Shoshone-Bannock Tribes were responsible for placing eggs in incubators, caring for eggs during incubation, and documenting hatching rates.

The IDFG provided daily staffing for the culture of captive-reared chinook salmon. Project fish were reared using standard fish culture practices and approved therapeutants (for an overview of standard methods see Leitritz and Lewis 1976; Piper et al. 1982; Erdahl 1994; Bromage and Roberts 1995; McDaniel et al. 1994; Pennell and Barton 1996). Fish were fed a standard commercial diet produced by BioOregon (Warrenton, OR) until they reached approximately 160 g after which time they received a special brood diet enhanced with natural flavors from fish and krill. Rearing tank size, density, and food ration varied with fish age, and were managed to promote optimum growth and for the attainment of program objectives and goals. Routine inventories were conducted in which fish were anesthetized, weighed to the nearest 0.1 g, and measured to the nearest 1 mm fork length to track growth and to insure that projected weights tracked closely with actual weights.

Table 2.–Summary of fish transfers conducted by the chinook salmon captive rearing project during 2001. LEM – Lemhi River, WFYF – West Fork Yankee Fork Salmon River, MAN – Manchester Marine Experimental Station, EAG – Eagle Fish Hatchery. NP, NE and SN refer to natural parr, natural egg, and safety net groups, respectively.

Source Stream	Brood Year	EAG to MAN	Transfer Date	MAN to EAG	Transfer Date	EAG to WFYF	Transfer Date
LEM-NP	1996			7	Jun. 06		
LEM-NP	1997			27	Jun. 06		
LEM-NP	1997			3	Aug. 02		
LEM-NP	1998			20	May 07		
LEM-NP	1998			5	Aug. 02		
LEM-NE	1999	10	Apr. 30				
LEM-NE	1999	200	May 10				
WFYF-NP	1996					4	Aug. 17
WFYF-NP	1997			33	Jun. 06	42	Aug. 17
WFYF-NP	1997			4	Aug. 02		
WFYF-NP	1998			26	May 11	43	Aug. 17
WFYF-NP	1998			9	Aug. 02		
WFYF-SN	1999	11	Apr. 30				
WFYF-SN	1999	231	May 07				
EFSR-NP	1998			10	May 07		
EFSR-NP	1998			8	Aug. 02		
EFSR-SN	1998			9	May 11		
EFSR-NE	1999	11	Apr. 30				
EFSR-NE	1999	102	May 07				
EFSR-SN	1999	10	Apr. 30				
EFSR-SN	1999	55	May 10				

Two experimental procedures were undertaken during this reporting period to address the asynchronous spawn timing of captive- and ocean-reared chinook salmon. The first involved monitoring the physiological development of anadromous returnees to the IDFG Rapid River Hatchery and of captive-reared chinook salmon. Blood plasma and pituitary glands were collected to measure sex hormone levels along with ovarian and testicular tissue for histological examination. Samples were collected monthly between April and September at the Rapid River Fish Hatchery. Identical samples were collected from captive-reared fish in April and August. By monitoring differences in how these two groups develop we hope to identify when their levels of maturation diverge. Once this is known, it may be possible to modify our culture practices to prevent this disconnect. The second experimental procedure involved manipulating the water temperature experienced by captive-reared adults during their final fresh water maturation. Maturing fish from the Lemhi and West Fork Yankee Fork Salmon rivers were divided into treatment and control groups, which were held on chilled (~ 9.0°C) and ambient (~13.5°C) water, respectively. Both groups represented the entire size

range of fish present in culture and contained approximately equal numbers of fish. Those from the Lemhi River group were retained in the hatchery for inclusion in physiological sampling and to compare the maturation dates of test and control groups in the hatchery environment. Fish from the West Fork Yankee Fork Salmon River were given a color/numeric mark that allowed observers to identify the individual and the experimental group it belonged to and released into their natal stream for volitional spawning.

Three types of tags were utilized in the captive rearing project during this reporting period including passive integrated transponder (PIT), Peterson disc, and radio transmitters. PIT-tags were injected into the peritoneal cavity of juvenile chinook salmon, using standard IDFG equipment and procedures, for individual identification and group tracking. Three culture groups of brood year 2000 juveniles were PIT-tagged on two dates in 2001 (Table 3). Fish to be released into the West Fork Yankee Fork Salmon River were fitted with disc tags on August 2, 2001, and these tags were used to differentiate individuals and groups released. Color combinations identified the brood year and experimental group each fish belonged to and a unique number on each tag identified the individual (Table 4). Stainless steel pins were inserted through the musculature of the dorsal surface near the midpoint of the dorsal fin and between the pterygiophores. Paired tags (color and number) were anchored to this pin on either side of the fish to allow identification from either side. Disc tags also facilitated the identification of post-spawn adults. Finally, radio transmitters were inserted into the stomachs of 19 mature adults to be released into the West Fork Yankee Fork Salmon River at the time they received their disc tags. Fish receiving radio transmitters represented a cross section of brood years, experimental treatments, and sizes (Table 4). Radio-transmitters were used to provide an estimate of how rapidly fish moved upstream and allowed us to locate individuals holding in logjams and undercut banks that would not have otherwise been detectable. Radio-transmitters were also useful in locating post-spawn carcasses or predation remains to determine the developmental state or how completely spawned the individual was at death.

Table 3.–Number, source stream, and culture group type of brood year 2000 juvenile chinook salmon PIT-tagged in the IDFG captive rearing project during 2001. Source streams include the West Fork Yankee Fork Salmon River (WFYF), Yankee Fork Salmon River (YFSR) and East Fork Salmon River (EFSR). All culture groups were collected as eyed-eggs, and are referred to as natural egg collections (NE).

Source Stream	Tag Date	Number
EFSR-NE	6/22/01	239
EFSR-NE	6/25/01	239
WFYF-NE	6/22/00	294
YFSR-NE	6/22/00	221

Table 4.–Tag and identification summary for captive-reared chinook salmon released for volitional spawning in the West Fork Yankee Fork Salmon River. All fish were disc- and radio-tagged on August 2, 2001, and released on August 17, 2001. Disc-tag colors included W – white, B – blue, Y – yellow, O – orange. Treatment group refers to the water temperature experienced during freshwater maturation at the Eagle Fish Hatchery. Test groups (T) were held on chilled (~9.0°C) water. Control groups (C) were held on ambient temperature well water (~13.5°C). Brood year 1997 and 1998 fish with tri-color disc tags were not included in the temperature study because it was determined they were maturing in a second sort, and would have differed in the amount of time held under experimental conditions. Fish from brood year 1996 (also with tri-color tags) were excluded due to low numbers and generally poor overall condition.

PIT-Tag Code	Brood Year	Disc Color	Disc Number	Transmitter Frequency	Treatment Group
5160323E26	BY97	B/W	54		T
516032073E	BY97	B/W	70		T
515C2D5469	BY97	B/W	64		T
515B5A581F	BY97	B/W	87		T
515B4D735E	BY97	B/W	96		T
515F556264	BY97	B/W	78		T
515B6F5420	BY97	B/W	88		T
5160295A0E	BY97	B/W	79		T
515B514E6B	BY97	B/W	72	151.412	T
515C024A40	BY97	B/W	52	151.313	T
515C367B69	BY97	B/W	84		T
515B4C081F	BY97	B/W	71	151.253	T
51602C3E76	BY97	B/W	76		T
51603C512B	BY97	B/W	51		T
51603C723F	BY97	B/W	62		T
516027574D	BY97	B/W	56		T
515B3F1660	BY97	B/W	57	151.533	T
515D343E2A	BY97	B/W	82	150.513	T
3D9.1BF0EC55AE	BY98	Y/W	38		T
3D9.1BF0EC2DCA	BY98	Y/W	22		T
3D9.1BF0EC414A	BY98	Y/W	02		T
3D9.1BF0EC4EBE	BY98	Y/W	50		T
3D9.1BF0ED3FD7	BY98	Y/W	44		T
3D9.1BF0EC3EC0	BY98	Y/W	26	150.884	T
3D9.1BF0ED4E84	BY98	Y/W	34		T
3D9.1BF0ED1E06	BY98	Y/W	28		T
3D9.1BF0EC5EC8	BY98	Y/W	24		T
3D9.1BF0ED2940	BY98	Y/W	30		T
3D9.1BF0ECE747	BY98	Y/W	40		T
3D9.1BF0EC2DEA	BY98	Y/W	42	151.394	T
3D9.1BF0EC46AE	BY98	Y/W	20	151.895	T
3D9.1BF0EE3D42	BY98	Y/W	04		T
3D9.1BF0EE3036	BY98	Y/W	12		T

3D9.1BF0ED4A37	BY98	Y/W	32		T
3D9.1BF0DFF436	BY98	Y/W	46	151.975	T
3D9.1BF0DEFDF4	BY98	Y/W	14	151.725	T
515F61451D	BY97	O/W	103		C
515B4D5F01	BY97	O/W	140	150.390	C
515B565418	BY97	O/W	135	150.080	C
515C270C18	BY97	O/W	143		C
515D464B6A	BY97	O/W	131		C
515B7F7F1E	BY97	O/W	111		C
515C2B0E77	BY97	O/W	145		C
515F58397D	BY97	O/W	107		C
515C256C05	BY97	O/W	141		C
515B4C3210	BY97	O/W	123	150.581	C
515B401771	BY97	O/W	149	151.043	C
515D3C4A63	BY97	O/W	115	150.802	C
516025334A	BY97	O/W	101		C
51603C5626	BY97	O/W	125		C
5160293840	BY97	O/W	117		C
515C642758	BY97	O/W	129		C
5160355F00	BY97	O/W	105		C
515B446363	BY97	O/W	139		C
5160302057	BY97	O/W	137		C
3D9.1BF0E0E008	BY98	O/B	173	151.644	C
3D9.1BF0EC3F89	BY98	O/B	175	150.260	C
3D9.1BF0DF4945	BY98	O/B	155	151.604	C
3D9.1BF0EC4114	BY98	O/B	171		C
3D9.1BF0EC33BF	BY98	O/B	195		C
3D9.1BF0EE6FD4	BY98	O/B	169		C
3D9.1BF0ED4BA6	BY98	O/B	151		C
3D9.1BF0EC55BA	BY98	O/B	183		C
3D9.1BF0EC313B	BY98	O/B	185		C
3D9.1BF0ED1908	BY98	O/B	174		C
3D9.1BF0ED461F	BY98	O/B	193		C
3D9.1BF0ED3F6C	BY98	O/B	197	151.563	C
3D9.1BF0ED4C6A	BY98	O/B	167		C
3D9.1BF0ECD37C	BY98	O/B	159		C
3D9.1BF0ECEC3D	BY98	O/B	163		C
3D9.1BF0EC45B3	BY98	O/B	179		C
223F3D325D	BY96	B/W/B	58		
2240581F06	BY96	B/W/B	77		
2240790327	BY96	B/W/B	97		
22407A545E	BY96	B/W/B	75		
51603A385F	BY97	B/W/B	146		
51600C5A01	BY97	O/W/B	106		
515F597910	BY97	O/W/B	106		
515F641B6A	BY97	O/W/B	124		
51602E0230	BY97	O/W/B	122		
3D9.1BF0EC3F02	BY98	Y/B/W	19		

3D9.1BF0EC431E	BY98	Y/B/W	33
3D9.1BF0EC5C42	BY98	Y/B/W	37
3D9.1BF0ED3798	BY98	Y/B/W	11
3D9.1BF0EC3C1C	BY98	Y/B/W	13
3D9.1BF0ED3C16	BY98	Y/B/W	29
3D9.1BF0ED4E5F	BY98	Y/B/W	25
3D9.1BF0ECDAFE	BY98	Y/B/W	39
3D9.1BF0EDB083	BY98	Y/B/W	23

RESEARCH EFFECTS ON STUDY ANIMALS

Disturbances to ESA-listed study animals were kept to a minimum during all phases of the project. While in culture, disturbance was minimized by tank configuration and limiting the number of times fish were handled. Additionally, fish were anesthetized during each handling event to further reduce stress and the potential for injury. Handling occurred twice during an approximate four-week period for maturation sorting and infrequently throughout the remainder of the year during tank cleanings. Tanks were also shade covered to minimize disturbance by normal hatchery operations and to provide refuge from bright sunlight.

We attempted to determine the cause of death in all captive-reared chinook salmon mortalities. Fish that died in culture were sent to the IDFG Fish Health Laboratory to be screened for bacterial and viral agents. Hatchery deaths, during the reporting period, were attributed to handling, culling, *Aeromonas* spp., and some undetermined causes. Mortality associated with clinical disease was uncommon except for one *Aeromonas* outbreak that followed their first maturation sort. Carcasses recovered after release into the West Fork Yankee Fork Salmon River were measured, examined for evidence of spawning and degree of spawning completion, and examined to determine cause of death. Fish were then returned to the stream to decompose naturally. In most cases, field deaths were attributed to predation based on the visible wounds. Some fish also died 'natural' deaths, which are inevitable after chinook salmon spawn.

Maturing captive-reared individuals were released into the West Fork Yankee Fork Salmon River to assess their spawning behavior and interactions with wild conspecifics. Frequent observations were made of these fish. Minimizing disturbances while attempting to observe normal activity was crucial. Field workers obscured their presence, and care was taken to approach fish slowly taking advantage of disguising vegetation as much as possible. In no cases were live fish handled or unnecessarily disturbed.

The West Fork Yankee Fork Salmon River maintains a remnant population of wild chinook salmon, but sufficient, high quality, spawning habitat is available to accommodate spawning by both wild and captive-reared adults. Additionally, captive-reared fish were isolated above the main concentration of wild adults in an area of

abundant historic spawning but little recent use by a blocking weir. Trap boxes built into the weir provided fish passage, with all fish being allowed to move above the weir and resident fish or wild chinook salmon could pass downstream. Study fish attempting to move downstream were returned to the river above the weir.

PROJECT COMPLICATIONS

The most significant problem encountered during 2001 involved poor egg development in Lemhi River females, which were used in physiological comparisons with ocean-reared returnees and in spawn timing comparisons between the two temperature groups. Visual assessment of ovarian development revealed lower egg quality than was anticipated. Developmental deficiencies were consistently more severe in fish reared in saltwater, and were generally more severe in the left ovary. The causative mechanism behind this asymmetry is unknown, but many saltwater-reared females had stomachs distended with what appeared to be water. Poor ovarian development may have been caused by blood-flow restrictions as the distended stomachs pressed the ovaries against the body wall. The arrangement of organs in the visceral cavity would cause these restrictions to be more severe on the left side. Poor egg development complicated the project on several fronts. First, it may have affected or been affected by hormone levels, which could exacerbate or mask developmental differences between captive- and ocean-reared individuals, and potentially confound comparisons between the two groups. Second, the poor egg quality resulted in significantly fewer eyed-eggs produced by hatchery crosses of maturing individuals than was anticipated.

Access to spawning areas in the East Fork Salmon River remains problematic, and many redds that may have been suitable for egg collections were inaccessible due to landowner non-cooperation. However, this situation appears to be improving as property ownership in the riparian corridor changes and as IDFG outreach and education programs begin to improve relationships between landowners and the Department. The relatively large number of spawning adults this year produced sufficient redds in areas we have access for our brood sourcing needs, but access may become limiting if chinook salmon escapement returns to the level of recent 10 year averages.

While these problems impacted study efficiency, we are aware of no unforeseen consequences of our activities. Study goals were accomplished despite these problems, and no evidence of research activities having any unforeseen or unintended impacts on the stream environment or other ESA-listed species was observed.

PRELIMINARY DATA ANALYSIS

Observations of captive-reared chinook salmon in the West Fork Yankee Fork Salmon River revealed that their behavior and habitat associations changed over time in

a manner consistent with advancing maturation, and that when spawning they behaved similarly to wild fish. Experimental water temperature manipulations during final maturation in fresh water to advance the spawn timing of captive-reared fish produced mixed results, and as such should not be abandoned without additional investigation.

General behavior and habitat association data were collected during daily observations of captive-reared chinook salmon released into the West Fork Yankee Fork Salmon River. The study section was 9.6 km long, and was divided into six units of approximately equal length. Data collection began approximately 24 h after fish were released, and all six units were monitored every two days. When a shoreline observer detected a fish, it was observed for 5 min, and its general activity and habitat association was recorded. This provided a standardized observation criterion on which to base behavior and habitat use comparisons over time. Fish behavior and habitat associations changed over time in a manner that reflected their changing requirements as they neared spawning. Early in the study, fish were generally observed holding position or moving (Figure 1), and were usually associated with pools or large woody debris (Figure 2). As the study progressed, spawning related behaviors including courting, and maintaining or holding on redds became their dominant activities (Figure 1). During this time, fish were mainly associated with tailouts although pools remained somewhat important as resting and staging areas (Figure 2).

We observed and documented eight unique spawning events involving captive-reared females: three with wild males and five with captive-reared males. We attempted to observe reproductive behavior for at least 1-2 h prior to spawning and for 30 min post spawning to ensure their entire range of behavior was observed and to provide sufficient observation time to compare the behavior of both groups of males. Behaviors quantified included male courtship (quivers and crossovers), female digging frequency and any instances of aggression. After the initial 5 min assessment of behavior and habitat association, observations were separated into 10 min periods to provide a mechanism detect changes in behavior frequency leading up to and following spawning. Our observations showed that captive-reared males displayed the same courtship behaviors as wild males, but the frequency of behaviors differed between the two groups relative to the time until spawning (Figure 3). The frequency of quivers and crossovers by wild males generally increased as spawning approached with a pronounced spike immediately prior to spawning (Figure 3). Courtship frequencies by captive-reared males remained constant or declined slightly during the period leading up to spawning, although the spike immediately prior to spawning was observed (Figure 3). The largest difference between the two groups of males was that captive-reared males were much less aggressive toward other chinook salmon or resident fish than were wild males (Figure 3).

Peak courting frequencies observed in captive-reared males were similar to those observed in ocean-reared hatchery chinook salmon that spawned in experimental channels (Berejikian et al. 2000). However, these fish displayed a pattern of increasing courtship frequency similar to that of the wild males in this study. Reduced frequencies of courtship and aggression have also been observed in comparisons of farmed and

wild chinook (Chebanov and Riddell 1998) and Atlantic salmon (*Salmo salar*) allowed to spawn naturally (Fleming et al. 1996).

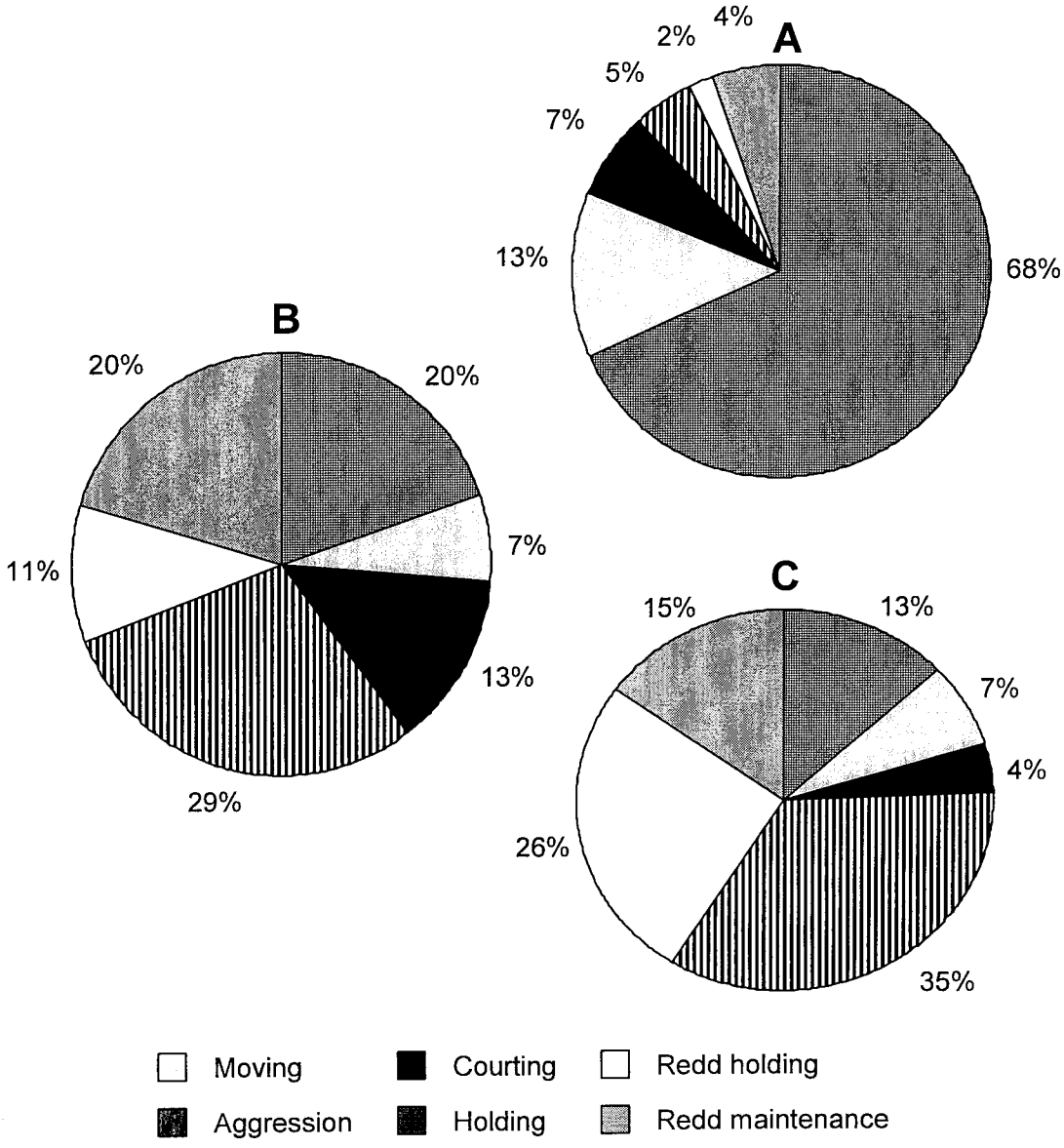

Figure 1.–General behaviors of captive-reared chinook salmon released into the West Fork Yankee fork Salmon River in the summer of 2001. Data were collected during standardized observation intervals. The charts represent information from the following time periods A: August 19 – September 1, B: September 2 – September 15, and C: September 16 – September 23.

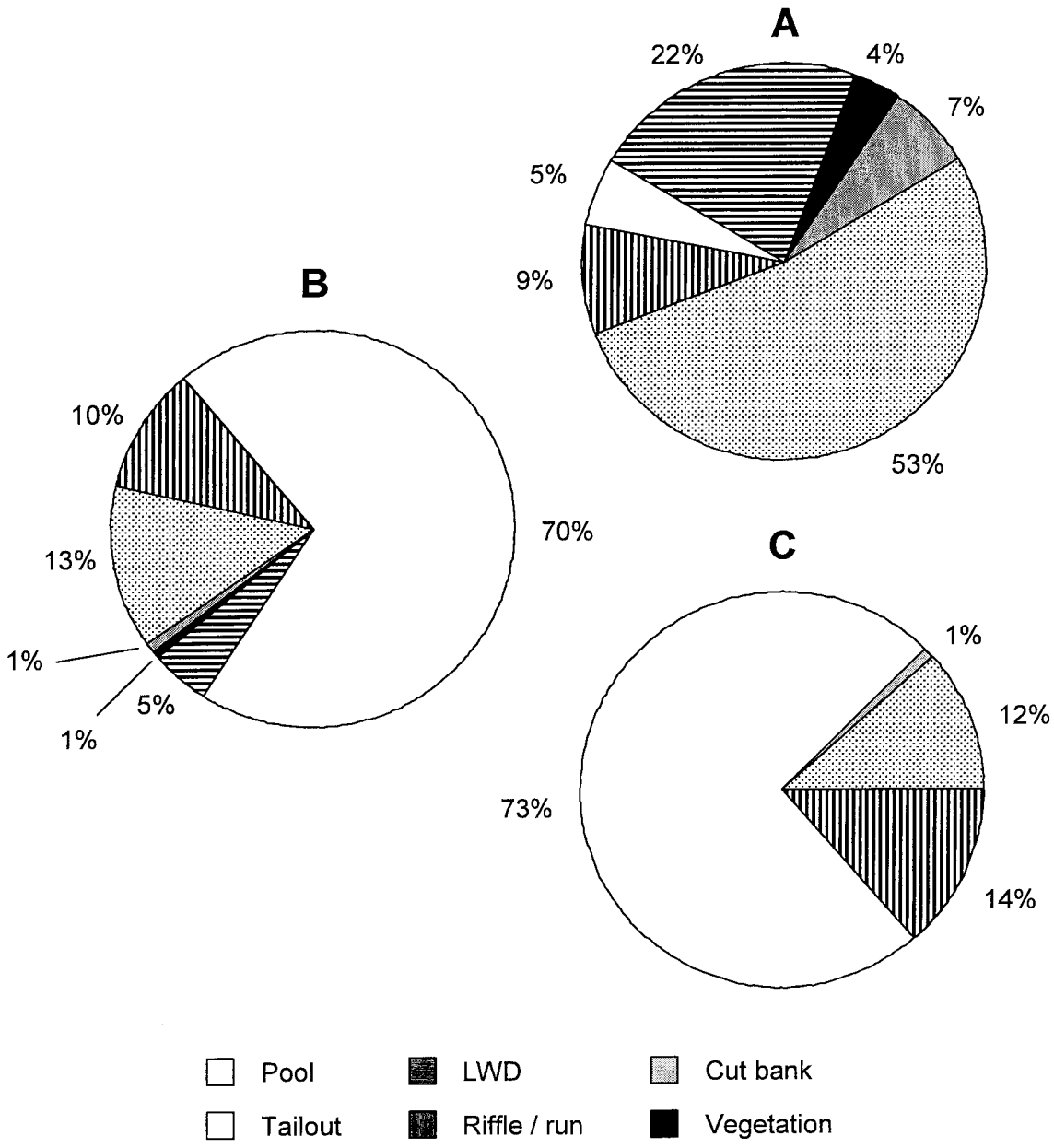

Figure 2.–Habitat associations of captive-reared chinook salmon released into the West Fork Yankee Fork Salmon River in the summer of 2001. Data were collected during standardized observation intervals. The charts represent information from the following time periods, A: August 19 – September 1, B: September 2 – September 15, and C: September 16 – September 23.

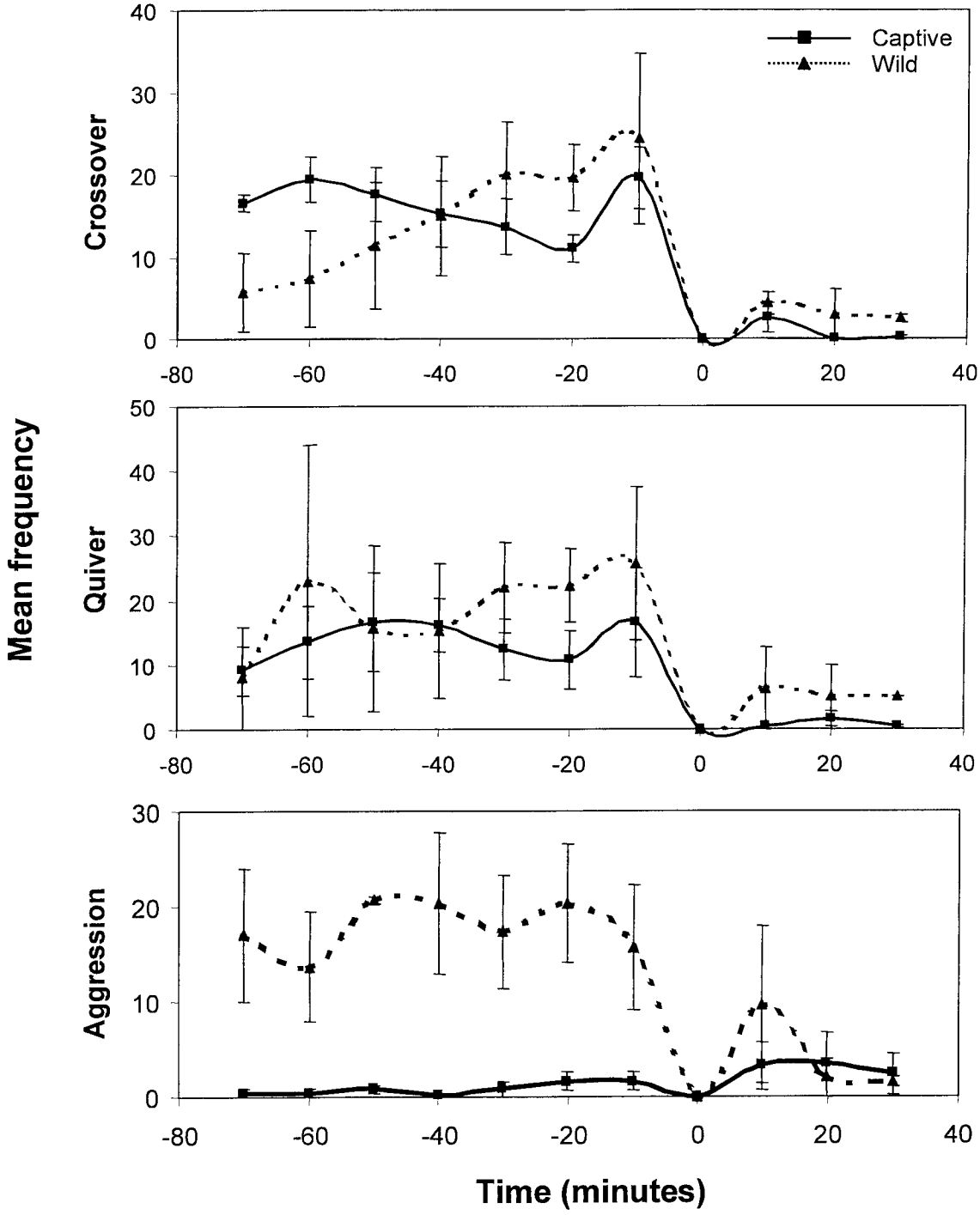

Figure 3.–Mean (± S.E.) frequencies of courting behavior and aggression in captive-reared and wild chinook salmon males observed spawning with captive-reared females in the West Fork Yankee Fork Salmon River, August – October 2001. Time zero is spawning, and negative and positive numbers are minutes prior to and post spawning, respectively.

Captive-reared females displayed digging patterns similar to those reported elsewhere in the literature. Study females made nest digs approximately every 2-3 min until egg deposition, then females proceeded to cover dig almost continuously for about 10 min, and maintained elevated digging frequencies for at least 30 min (Figure 4). This general behavior pattern has been reported in chinook (Berejikian et al. 2000) and coho salmon (*Oncorhynchus kisutch*; Berejikian et al. 2001), and is probably common to all stream spawning salmonids.

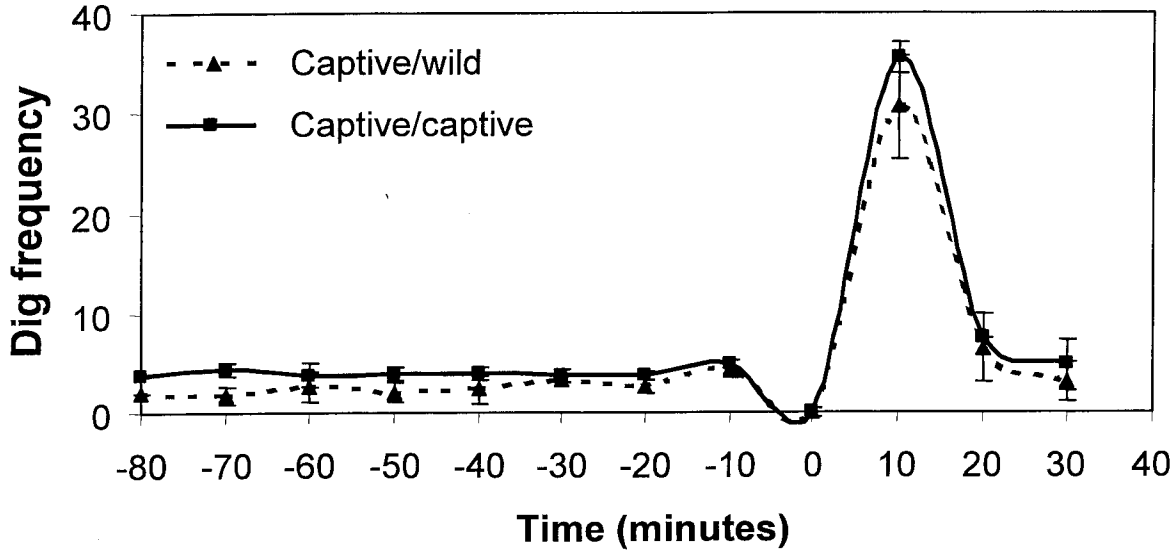

Figure 4.– Mean (± S.E.) frequencies of digging by captive-reared, female chinook salmon observed spawning with captive-reared (solid line) and wild males (dashed line) in the West Fork Yankee Fork Salmon River, August – October 2001. Time zero is spawning, and negative and positive numbers are minutes prior to and post spawning, respectively.

In response to past results where captive-reared chinook salmon spawned several weeks later than wild fish in the same or nearby streams (Hassemer et al. 1999, 2001), we attempted to advance spawn timing by holding maturing adults on chilled water (Taranger et al. 1999). Additional water chilling capacity was added at Eagle, and maturing brood year 1997 and 1998 fish from the Lemhi and West Fork Yankee Fork Salmon rivers were assigned to test (chilled) or control (ambient temperature) groups. Mean group weights, within stock and brood year, did not differ significantly (two sample *t*-test; $P > 0.05$; Systat 2000). Test groups were held at temperatures averaging 8.9°C (range 8.3–14.1, SD = 0.61), and control groups were maintained on ambient temperature well water, which averaged 13.8°C (13.3–14.7, SD = 0.30; Figure 5). A chiller failure on July 3, 2001 lasting 41 h 30 min allowed the test tank to reach the maximum temperature recorded, and a second failure lasting 2 h 30 min on August 9, 2001 allowed test tank temperatures to reach 11.5°C. Excluding these times from the dataset provides a more typical regime experienced by the chilled water groups (mean 8.8°C, range 8.3–9.6, SD = 0.28).

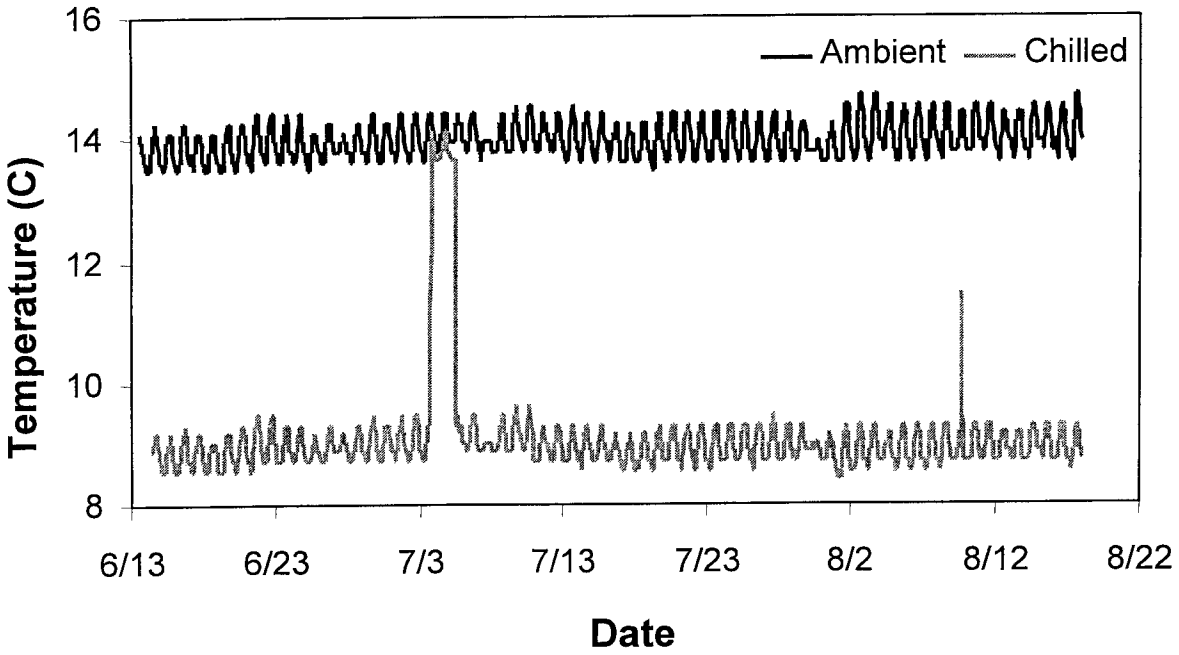

Figure 5.–Chilled and ambient tank water temperatures experienced by maturing captive-reared chinook salmon at the Eagle Fish Hatchery during their final freshwater maturation, June – August, 2001.

The effects of chilled water on spawn timing remain unclear, but results to date suggest this is a strategy worth pursuing, potentially with the addition of concurrent photoperiod manipulations. While field observations of spawning dates for the two groups of females in the West Fork Yankee Fork Salmon River did not appear to differ, it is important to note that all treatment females except one spawned by September 5, 2001, while control females continued to initiate spawning until September 17, 2001 (Table 5). However, Lemhi River adults held on site at Eagle to compare the maturation timing of the two temperature groups produced no clear results. This experiment was hampered by a combination of small sample size and having most of the "quality" females (based on size and appearance) sacrificed for physiological comparisons with anadromous returnees. However, treatment males from this stock did begin running milt approximately 10 – 14 days earlier than those in the control group. A total of 25 Lemhi River females (11 treatment and 14 control) were spawned in 2001 (Table 6), producing 21,500 green eggs. An additional control female was culled during spawning because of retained and polarized eggs (Table 6). Eggs from individual females were divided into two sub-lots and fertilized by different males. Multiple males (from the same temperature treatment as the female) acted as an aid in identifying which parent contributed non-viable gametes in cases of low (or no) fertilization. Overall egg survival to the eyed stage of development was 37.9% (range 0% - 88%) for all fish combined. Mean egg survival to the eyed stage of development (by female) was 24.3% and 37.0% for treatment and control fish, respectively, and did not differ significantly (*t*-Test; P =

0.3484; Systat 2000) between the groups. Information pertaining to the performance of individual spawn crosses is contained in Table 6.

On October 15 and 16, 2001 eggs were collected from a portion of the redds spawned by captive-reared chinook salmon to estimate egg fertilization rate and survival to the eyed stage of development. Based on accumulated thermal exposure, we estimated that eggs in eight of 18 redds spawned by study fish had progressed to the eyed stage of development and were suitable for sampling. Eggs were collected from five of the eight redds. The percentage of live eggs ranged from 0% - 89% (Table 7). All of the eggs that were alive at the time of collection were fertilized (as determined by the presence of a visible embryo within the egg).

One redd contained no live eggs although it appeared to have been constructed in extremely high quality habitat and was very well developed. Sampling in this redd revealed that the tailout the redd was constructed in had a thin (approximately 7 cm) layer of gravel/cobble armoring over a large, decayed log. Once the probe was worked through the armoring, only wood chips and dead eggs were lifted out of the substrate. The buried woody debris was apparently quite large, as sampling at several locations within and around the redd yielded only wood chips below the armoring layer.

Table 5.–Date of first redd initiation by captive-reared chinook salmon in the West Fork Yankee Fork Salmon River, August – September, 2001. Control fish were held on ambient temperature well water (~13.8°C) at the Eagle Fish Hatchery during final freshwater maturation, while treatment fish were held on chilled water (~8.9°C). Late arrivals were fish identified as maturing during a second sort and not transferred to the Eagle Fish Hatchery in time to be included in the temperature experiment.

Date	Female
8/30/01	Control
8/31/01	Late Arrival
9/1/01	Treatment
9/1/01	Treatment
9/2/01	Treatment
9/2/01	Control
9/4/01	Control
9/5/01	Treatment
9/5/01	Treatment
9/7/01	Control
9/8/01	Late Arrival
9/9/01	Control
9/9/01	Control
9/10/01	Control
9/13/01	Late Arrival
9/14/01	Control
9/17/01	Test
9/17/01	Control

Table 6.–Summary of spawning activities involving captive-reared, Lemhi River, chinook salmon at the Eagle Fish Hatchery in 2001. Fish known to be maturing were separated into two groups; one held on chilled water and the other on ambient temperature well water to determine the effect of temperature on maturation timing. Both males and females from brood years (BY) 1997, and 1998 matured in 2001 along with several females from BY 1996. Mean survival estimates were computed using geometric means.

Spawn date	Female origin	Female BY	Group	Female weight (g)	Total fecundity	Male origin	Male BY	Green eggs	Eyed eggs	Mean survival
9/14/01	NMFS	BY97	Chilled	1188	1177	NMFS	BY98	523	443	0.833
						NMFS	BY98	504	413	
9/14/01	NMFS	BY97	Chilled	1145	909	NMFS	BY98	310	5	0.016
						NMFS	BY98	299	5	
9/14/01	NMFS	BY97	Ambient	835					Not Spawned	
9/14/01	NMFS	BY96	Ambient	1048	1431	NMFS	BY98	480	26	0.057
						NMFS	BY98	478	28	
						-	-	473	28	
9/17/01	NMFS	BY96	Ambient	1400	1819	NMFS	BY98	540	471	0.880
						NMFS	BY98	540	474	
						-	-	539	479	
9/21/01	NMFS	BY97	Chilled	1041	984	NMFS	BY98	406	122	0.296
						NMFS	BY98	368	107	
9/24/01	NMFS	BY98	Chilled	817	1244	NMFS	BY98	358	103	0.281
						NMFS	BY98	336	92	
9/24/01	NMFS	BY97	Ambient	1096	1379	NMFS	BY98	529	472	0.880
						NMFS	BY98	520	451	
9/24/01	NMFS	BY97	Ambient	820	805	NMFS	BY98	293	218	0.740
						NMFS	BY98	277	204	
9/26/01	EAGLE	BY97	Ambient	671	1035	NMFS	BY98	235	2	0.009
						NMFS	BY98			
9/26/01	NMFS	BY98	Ambient	1373	2064	NMFS	BY98	250	36	0.217
						NMFS	BY98	214	70	

Table 6 (continued).–Summary of spawning activities involving captive-reared, Lemhi River, chinook salmon at the Eagle Fish Hatchery in 2001. Fish known to be maturing were separated into two groups; one held on chilled water and the other on ambient temperature well water to determine the effect of temperature on maturation timing. Both males and females from brood years (BY) 1997, and 1998 matured in 2001 along with several females from BY 1996. Mean survival estimates were computed using geometric means.

Spawn date	Female origin	Female BY	Group	Female weight (g)	Total fecundity	Male origin	Male BY	Green eggs	Eyed eggs	Mean survival
9/26/01	NMFS	BY97	Chilled	1403	1370	NMFS	BY98	520	0	0.000
						NMFS	BY98			
10/1/01	NMFS	BY97	Ambient	1281	825	NMFS	BY98	407	283	0.683
								388	260	
10/1/01	EAGLE	BY96	Ambient	98	1186	NMFS	BY98	525	0	0.000
						EAGLE	BY97	511	0	
10/1/01	EAGLE	BY96	Ambient	1030	1357	NMFS	BY98	653	0	0.000
						NMFS	BY97	654	0	
10/1/01	EAGLE	BY96	Ambient	1001	665	NMFS	BY98	335	0	0.000
						EAGLE	BY98		0	
10/1/01	NMFS	BY96	Ambient	1266	1856	NMFS	BY98	611	134	0.306
						NMFS	BY98	630	230	
								590	211	
10/4/01	EAGLE	BY97	Ambient	732	864	NMFS	BY98	326	0	0.000
						NMFS	BY98	308	0	
10/4/01	EAGLE	BY97	Chilled	1427	1786	NMFS	BY98	636	367	0.618
						NMFS	BY98	650	430	
10/4/01	EAGLE	BY97	Chilled	1135	1033	NMFS	BY98	396	99	0.229
						NMFS	BY98	387	81	
10/4/01	EAGLE	BY98	Chilled	1150	877	NMFS	BY98	127	0	0.000
						NMFS	BY98			
10/10/01	EAGLE	BY98	Ambient	811	1183	EAGLE	BY98	525	256	0.598
						NMFS	BY98	508	372	

Table 6 (continued).–Summary of spawning activities involving captive-reared, Lemhi River, chinook salmon at the Eagle Fish Hatchery in 2001. Fish known to be maturing were separated into two groups; one held on chilled water and the other on ambient temperature well water to determine the effect of temperature on maturation timing. Both males and females from brood years (BY) 1997, and 1998 matured in 2001 along with several females from BY 1996. Mean survival estimates were computed using geometric means.

Spawn date	Female origin	Female BY	Group	Female weight (g)	Total fecundity	Male origin	Male BY	Green Eggs	Eyed eggs	Mean survival
10/10/01	EAGLE	BY97	Chilled	1346	1527	NMFS	BY98	527	20	0.038
						NMFS	BY98			
10/10/01	NMFS	BY97	Chilled	895	263	NMFS	BY98	163	53	0.325
						NMFS	BY98			

Table 7.–Results from sampling redds spawned by captive-reared females in the West Fork Yankee Fork Salmon River. Treatment and control fish refer to those held on chilled and ambient temperature water, respectively, at the Eagle Fish Hatchery during final maturation. Eggs were collected October 15-16, 2001.

Redd	Live eggs	Dead eggs	% live	% Live fertilized	Female	Male
1	16	2	88.9	100	Control	Wild
2	9	22	29.0	100	Control	Treatment
3	25	10	71.4	100	Treatment	Wild
4	21	4	84.0	100	Control	Wild
5	0	35	0.0		Treatment	Unknown

COORDINATION WITH OTHER RESEARCH

Idaho and Oregon state, tribal, and federal fish managers met during 1993 and 1994 to discuss captive culture research and implementation in the Snake River basin. The outcome of those meetings was agreement that the Oregon Department of Fish and Wildlife (ODFW) would initiate a captive brood stock program for selected Grande Ronde River chinook salmon populations, and the IDFG would initiate a captive rearing research program for selected Salmon River chinook salmon populations. The primary focus of these programs was to evaluate each form of captive culture and its effectiveness at meeting population conservation objectives. The Chinook Salmon Captive Propagation Technical Oversight Committee (CSCPTOC) was formed to provide a forum of peer review and discussion of all activities and culture protocols associated with this program. Individuals from the Bonneville Power Administration, Columbia River Intertribal Fish Commission, IDFG, NMFS, ODFW, Shoshone–Bannock Tribes, University of Idaho, U.S. Fish and Wildlife Service, and Washington Department of Fish and Wildlife regularly attend CSCPTOC meetings, which are held approximately every other month. These frequent meetings foster cooperation between the agencies involved by providing regular information transfer and the opportunity to discuss project plans well in advance of their implementation.

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